compensating for the unbalance in the magnetic force by controlling an attracting force generated by the magnetic supporting coil so that a balanced magnetic force is applied to the rotor to reduce vibration thereof.

IN THE DRAWINGS:

Submitted herewith are copies of Figs. 4 and 10 of the drawings on which have been marked proposed drawing revisions. Upon approval of the revisions and allowance of the application, the formal drawings will be suitably revised.

ADDITIONAL FEES:

A check in the amount of $84.00 is enclosed to cover the cost of 1 independent claim in excess of 3. Should the check prove insufficient for any reason, authorization is hereby given to charge any such deficiency to our Deposit Account No. 01-0268.

REMARKS

By this supplemental response, applicants have canceled claims 15 and 16 and amended claims 10, 13 and 14 added by the last-filed response. In addition, applicants have added new claims 17-29. The specification has been further revised in editorial respects to improve the wording

and correct informalities and proposed revisions have been submitted in Figs. 4 and 10 to add a reference numeral and correct erroneously labeled elements.

Applicants respectfully submit that claims 8-14 and 17-29 patentably distinguish over the prior art of record.

The Barada patent cited by the Examiner in the last Action discloses a magnetic bearing apparatus comprising a rotor 11, a motor portion 13 provided in the rotor for rotating the rotor by a magnetic force, magnetic supporting coils 16a/16b for magnetically supporting the rotor in a radial direction in a predetermined position, and a magnetic support adjustment means for adjusting the magnetic force of the magnetic supporting coils so as to resist unbalance of the magnetic force.

The Hamilton patent was cited by the Examiner as disclosing a position sensor for a magnetic suspension system including a feedback loop having an unbalance force obtaining means which derives a signal representative of the applied force and includes a force sensor 72 and a force command signal 74. The Examiner pointed out that signals representative of the currents applied to the magnetic bearing coils and of the sensed force are used to derive the armature displacement signal by means of a control law, which permits replacement of inaccurate proximity transducers with a more accurate electrical circuit.

Neither Barada nor Hamilton, taken alone or in combination, discloses or suggests the novel aspects of the present invention.

Independent claim 17 recites a magnetic bearing apparatus comprising a rotor, a motor, magnetic supporting coils for magnetically supporting the rotor at a predetermined location, magnetic force unbalance determining means for determining unbalance in a rotary magnetic force generated by stator coils of the motor, the unbalance resulting from displacement of the rotor from the predetermined location, and radial position adjusting means for adjusting the magnetic force produced by the magnetic supporting coils to reduce the unbalance in the rotary magnetic force.

Independent claim 24 is similar to independent claim 8 in that it recites a magnetic bearing apparatus having composite magnetic force determining means for determining composite vectors of a magnetic force affecting the rotor based on the rotary magnetic field generated by the motor. However, claim 24 further recites that the magnetic support adjusting means adjusts the magnetic force produced by the magnetic supporting coils to offset for unbalance in the magnetic force affecting the rotor represented by the composite vectors of the magnetic force, to thereby reduce vibration of the rotor.

Independent method claim 29 recites a method for reducing or eliminating vibration by reducing unbalance in a magnetic force generated by the motor due to run-out of the rotor in a radial direction thereof, comprising the steps of using a radial position sensor to detect run-out of the rotor in the vicinity of the radial position sensor, determining run-out of rotor in the vicinity of the motor based on an output of the radial position sensor and a positional relationship between the motor and the radial position sensor, detecting unbalance in the magnetic force generated by the motor based on the run-out of the rotor in the vicinity of the motor, and compensating for the unbalance in the magnetic force by controlling an attracting force generated by the magnetic supporting coil so that a balanced magnetic force is applied to the rotor to reduce vibration thereof.

Accordingly, the inventive magnetic bearing apparatus and method determine or infer unbalance in a rotary magnetic force based on run-out or radial displacement of a rotor. In accordance with independent claims 8, 18 and 23, the inventive magnetic bearing apparatus detects unbalance in a rotary magnetic force applied to a rotor and adjusts a force generated by magnetic support coils to compensate for the unbalance. Method claim 29 recites steps for performing these functions. Claims 8 and 23 further recite means for inferring

composite vectors of the magnetic force affecting the rotor according to the rotary magnetic field applied to the rotor by the motor to detect the unbalance. Neither Barada nor Hamilton disclose these claimed features of the present invention.

As pointed out in the last-filed response, Hamilton discloses a position sensor and a feedback loop that derives a signal representative of an applied force and includes a force sensor 72 and a force command signal 74. In Hamilton, the control system originates its own output. In accordance with the present invention, composite vectors of a magnetic force affecting a rotor are determined in accordance with the magnetic field applied to the rotor by the motor.

Accordingly, neither Barada nor Hamilton discloses or suggests the claimed invention. Accordingly, applicants respectfully submit that claims 8-14 and 17-29 patentably distinguish over the prior art of record.

In view of the foregoing amendments and discussion, the application is now believed to be in condition for

allowance. Accordingly, favorable reconsideration and allowance of the claims are respectfully requested.

Respectfully submitted,

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MAILING CERTIFICATE

I hereby certify that this correspondence is being deposited with the United States Postal Service as first-class mail in an envelope addressed to: MS AMENDMENT FEE, COMMISSIONER FOR PATENTS, P.O. Box 1450, Alexandria, VA 22313-1450, on the date indicated below.

Debra Buonincontri
Name

Debra Buonincontri
Signature

May 12, 2003
Date

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FIG. 4

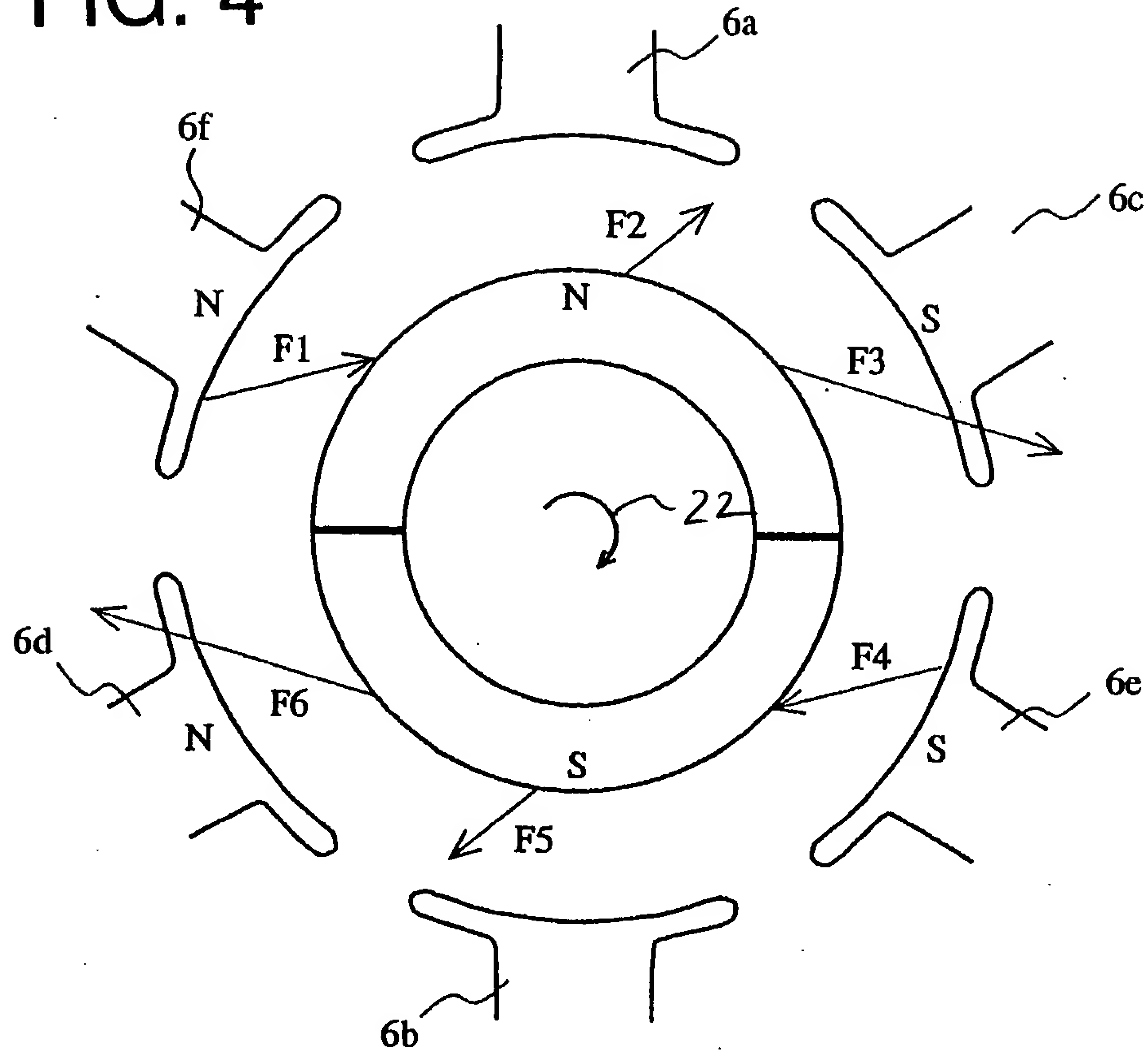

FIG. 5

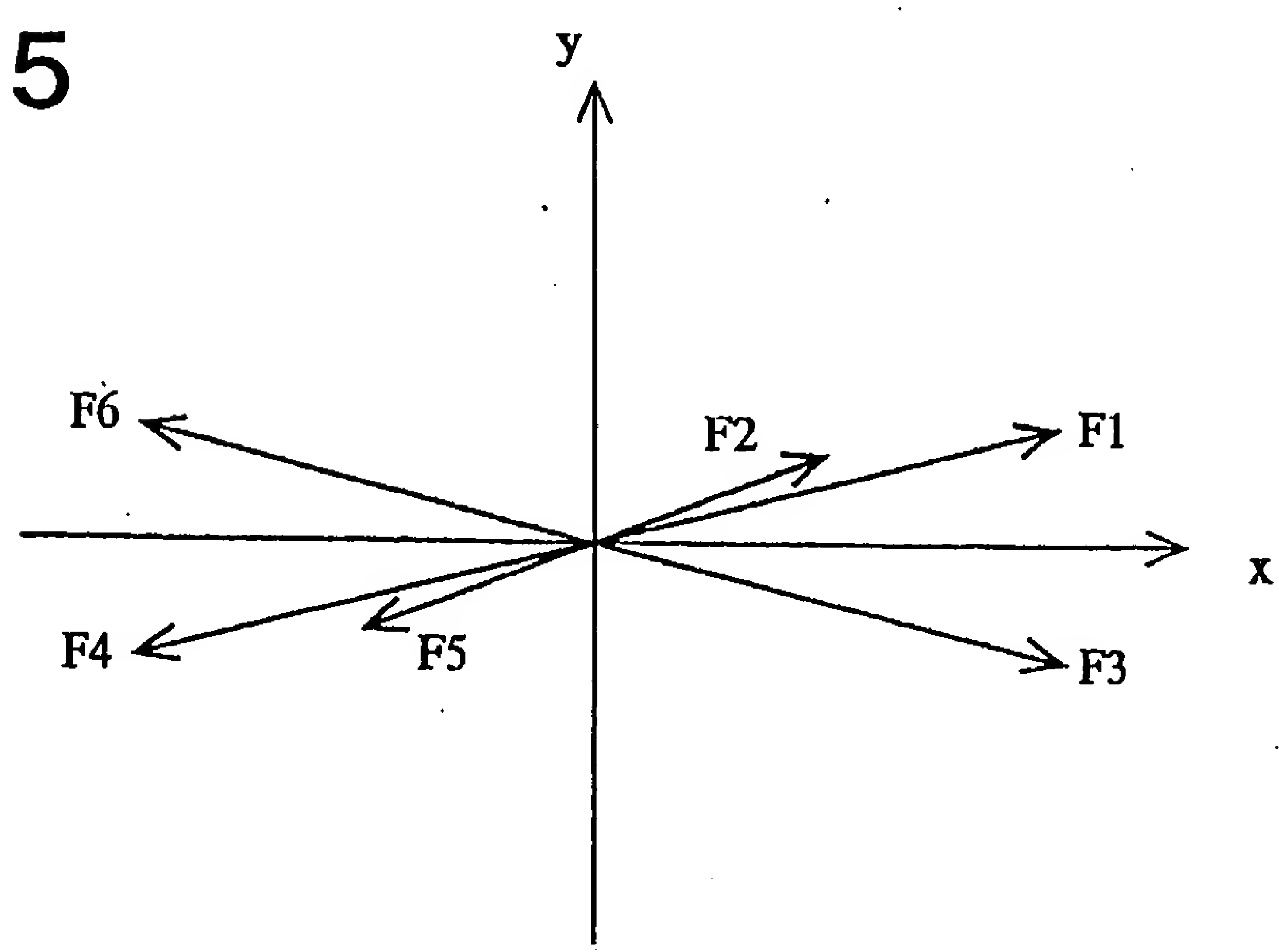

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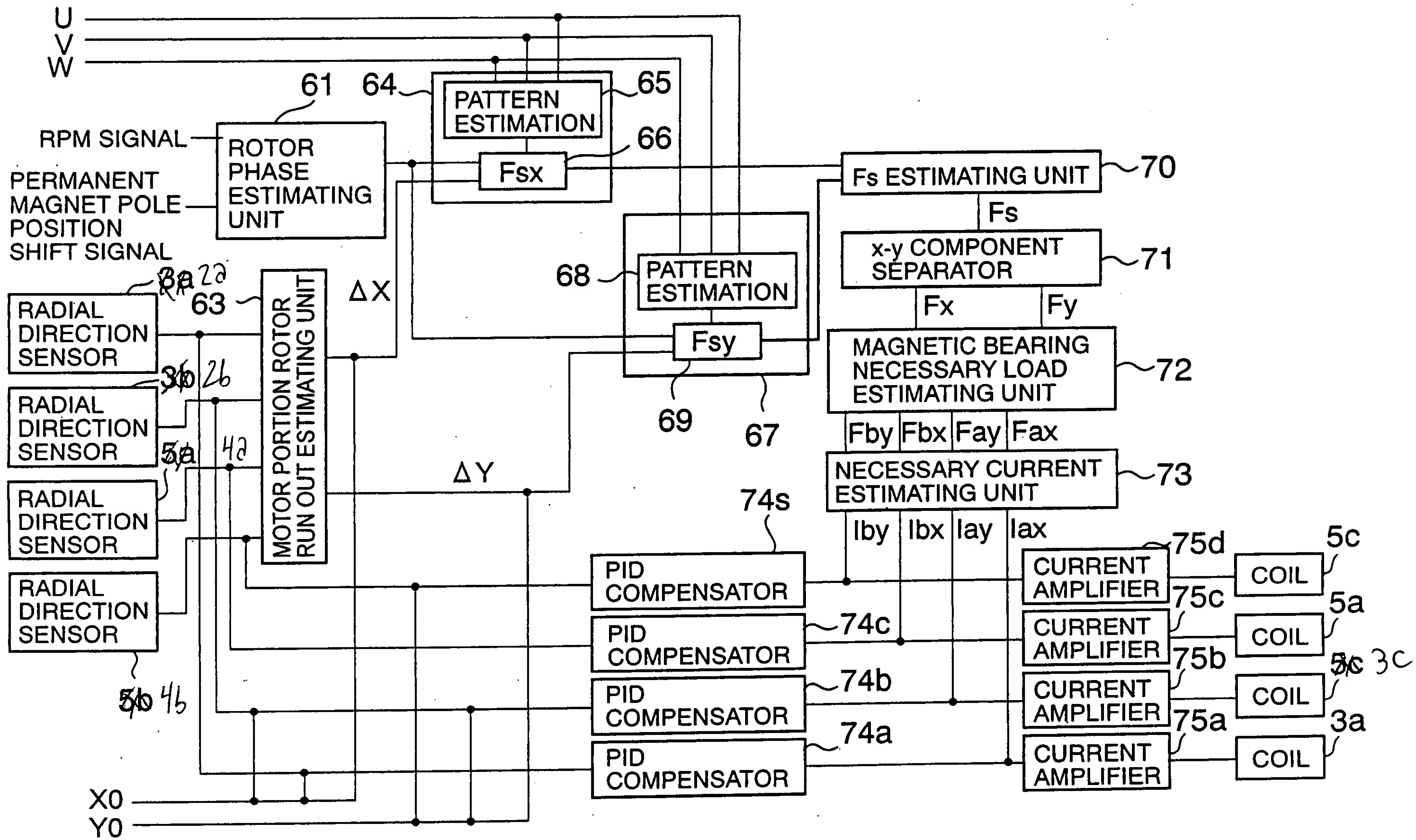
FIG. 10



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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

Paragraph beginning at page 4, line 17, has been amended as follows:

--[For the] The component ΔX having the frequency fr obtained through the band-pass filters is controlled to become the value expressed by the following Formula (2). Then, the attractive force of the coils is kept constant as indicated by Formula (3).--

Paragraph beginning at page 6, line 16, has been amended as follows:

--In order to attain the above-described object, according to the present invention, there is provided a magnetic bearing apparatus characterized by comprising a rotor, a motor portion provided in the rotor for rotating the rotor by a magnetic force, [magnetically] magnetic supporting coils for magnetically supporting the rotor in a predetermined position, [a] magnetic force unbalance obtaining means for obtaining an unbalance of the magnetic force generated in the motor portion by the rotor run-out in the radial direction from the predetermined position and [to be] applied to the rotor, and [a magnetically] magnetic support adjustment means

for adjusting the magnetic force of the [magnetically] magnetic supporting coils so as to resist the unbalance of the magnetic force.--

Paragraph beginning at page 7, line 5, has been amended as follows:

--If the magnetic bearing apparatus is thus constructed, [the] a force effective for resisting [the] unbalance of the attractive force between the rotor and the stator caused [generated] by run-out of the position of the rotor in the radial direction is [caused to generate] generated in the magnetic bearing to thereby make it possible to reduce the vibration of the stator.--

Paragraph beginning at page 8, line 10, has been amended as follows:

--Further, it is possible to calculate the run-out of the rotor in the motor portion by detecting the run-out of the rotor by a radial direction sensor and calculate it from the geometric positional relation among the motor portion, the radial direction sensor, and the rotor, and the run-out [this] value. If the run-out of the rotor in the motor portion is inferred in this way, it is possible to obtain the unbalance between the rotor and the stator in the motor portion from the

angle of the magnetic field and the rotational angle of the magnetic poles of the rotor and the value of this run-out vibration through calculation or experimental values. Then it is possible to control the bearing force of the magnetic bearing so as to offset the unbalance of the magnetic force. In addition, the unbalance of the magnetic force may be kept in the form of a database of the angle of the magnetic field, the rotational angle of the magnetic poles and the run-out vibration of the rotor as variables in advance. Then, when the unbalance of the magnetic force is obtained from the run-out vibration of the rotor, it is possible to obtain the unbalance from the database by using the angle of the magnetic field, the rotational angle of the magnetic poles and the amount of run-out at this time.--

Paragraph beginning at page 19 line 23, has been amended as follows:

--The method for seeking Fsx will now be described. Fsx is a function of three <u>variables including</u> [valuables of] X, the direction of the magnetic field generated by the coils 6 and the rotary angle γ from the maximum torque of the rotor 1 (assuming that the size of the magnetic field generated by the coils 6 is kept constant). This is <u>also</u> the case with respect to Fsy.--

Paragraph beginning at page 25 line 19, has been amended as follows:

--The rpm signal represents the rpm of the rotor 1 and the permanent magnet pole position switchover signal represents the timing when the switchover <u>or junction</u> position of the poles of the N-pole and S-pole of the permanent magnet 11 passes through the sensor installed within the motor. The position of the magnetic poles of the permanent magnet 11 is inferred from both signals. This is outputted to an Fsx calculation section 66 and an Fsy calculation section 69. Here, if the permanent magnet pole position switchover signal is counted, the rpm signal may be obtained and the rpm sensor per se may be dispensed with.--

Paragraph beginning at page 26 line 5, has been amended as follows:

--The radial directions sensors [3a and 3b] <u>2a and 2b</u> of the bearing portion 8 and the radial direction sensors <u>4a and 4b</u> [5a and 5b] of the bearing portion 9 are connected to a motor portion rotor run-out estimating unit 63. The xy components of the run-out of the rotor 1 in the bearing portions 8 and 9 are detected by means of the respective sensors. These values are inputted into the motor portion rotor run-out estimating unit 63. The motor portion 10 rotor

run-out estimating unit 63 calculates and outputs the run-outs ΔX and ΔY of the rotor 1 in the motor portion 10 on the basis of Formulae (4) and (5). Then, X0 and Y0 are added to ΔX and ΔY, and X-+ΔX and Y0+ΔY are inputted into an Fsx calculation section 66 and an Fsy calculation section 69, respectively.--

Paragraph beginning at page 27 line 8, has been amended as follows:

--An <u>Fsy</u> [Fsx] estimating section 67 is composed of a pattern estimating section 68 and the Fsy calculation section 69 and infers the magnetic force generated in the -x′ direction when the rotor 1 is swung in the y′ direction, i.e., Fsy in the same manner as in the Fsx estimating unit 64.--

Paragraph beginning at page 29 line 1, has been amended as follows:

--The <u>term</u> PID control means [the] control of the coil currents for causing the change of the magnetic attractive force between the rotor 1 and the coil 3 to be in proportion to the velocity and the run-out of the rotor. The magnetic bearing apparatus obtains the bearing force through [the] PID control. Namely, if the rotor 1 is swung [in] one <u>way in</u> [direction of] the radial direction, the magnetic force of the coil 3 is fed back and controlled so that this run-out is returned back <u>or eliminated</u>.--

Paragraph beginning at page 29 line 9, has been amended as follows:

--The output signal of the PID compensator 74a is amplified in the current amplifier 75a and a predetermined current is fed to the coil 3a [76a]. Then, the rotor 1 obtains the predetermined attractive force in the x direction of the bearing portion 8 and is supported at a predetermined air gap with respect to the coil 3.--

Paragraph beginning at page 29 line 17, has been amended as follows:

--A current value from the necessary current estimating unit 73 is added to the current value to be fed from the PID compensator 74a to the current amplifier 75a. Then, the magnetic field generated by the coil 3a [76a] is obtained by superimposing the bearing force for holding the rotor 1 in a predetermined position and the magnetic force Fax for offsetting the unbalance of the magnetic force caused by the magnetic field generated due to the motor portion 10.--

IN THE CLAIMS:

Claims 10, 13 and 14 have been amended as follows:

10. (Amended) A magnetic bearing apparatus according to claim 9; wherein the composite magnetic force

inferring means comprises a magnetic flux detector for detecting a magnetic flux existing in an air gap between a magnetic pole of the <u>rotor</u> [motor] and the stator coils, and second inferring means for inferring the composite vectors of the magnetic force affecting the rotor from the magnetic flux detected by the magnetic flux detector.

13. (Amended) A magnetic bearing apparatus according to claim 12; further comprising a radial position sensor for detecting movement of the rotor in the radial direction thereof <u>in the vicinity of the radial position sensor</u>; and inferring means for inferring movement of the rotor in the radial direction <u>in the vicinity of the motor</u> based on a positional relationship between the radial position sensor and the motor and an amount of movement of the rotor detected by the radial position sensor; and wherein the composite magnetic force inferring means comprises calculating means for calculating composite vectors of the magnetic force affecting the rotor on the basis of a rotational angle of magnetic poles of the <u>rotor</u> [motor], a magnetic field generated by the stator coils of the motor, and the movement of the rotor in the radial direction <u>in the vicinity of the motor</u> inferred by the inferring means.

14. (Amended) A magnetic bearing apparatus according to claim 13; wherein the calculating means calculates the composite vectors of the magnetic force affecting the rotor on the basis of a database of composite vectors of the magnetic force affecting the rotor and a relationship thereof to the radial movement of the rotor, the rotational angle of the magnetic poles of the rotor, and the magnetic field generated by the stator coils of the motor.